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Rolling Sheet Metal

The New Continuous Process

By DEAN S. HUBBELL, '28

The art of rolling steel into sheets was brought from Saxony to Wales, and later from Wales to the United States, and until recently, but few changes of consequence have been made since the conventional method got its start in 1750.

The present status of automobile manufacturing with its demand for better hot rolled sheets and tremendously increased volume has shown that the old method of sheet rolling with its slow, back-breaking manual operations must be radically changed in order to keep pace with modern industry.

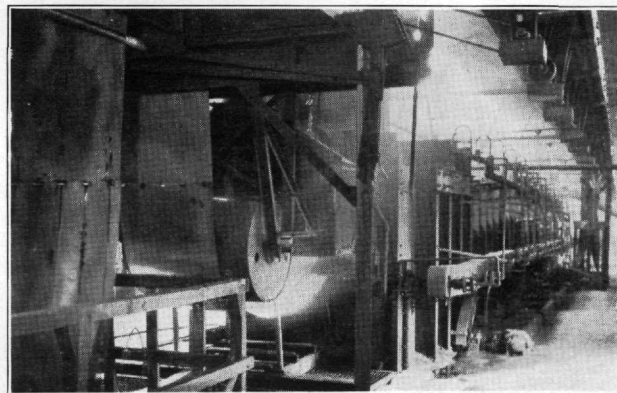
The American Rolling Mill Company, shortly before the entrance of this country into the World War, undertook the problem of developing a continuous process for making sheets, with the result that they have built a plant at Ashland, Ky., in the last 3 or 4 years, which is at present making sheet at the rate of 1 ton per minute.

This sheet is formed from the ingot by a continuous process and requires but one reheating in its journey from ingot to 20 gage sheet. A heated ingot runs the gamut of roll stands to 16 gage without reheating and finally with one reheating and five continuous passes is formed into 20 gage sheet.

The economic significance of this radical departure from the old method of sheet rolling can be appreciated by considering that the entire plant requires an operating crew of but 20 men, while the old method would require, in its hot mill crews alone, a total of 360 men to produce equivalent tonnage. Moreover no sheet and pair furnaces are required and the manual handling of the past is entirely eliminated.

In order to better understand the advantages of the continuous process the old method of operation should be considered briefly.

Sheet bars are the raw material used in the manufacture of sheets. They are received by the sheet makers usually in 30 foot lengths and in widths of about 8 inches and are cut into lengths weighing a certain number of pounds to corre-

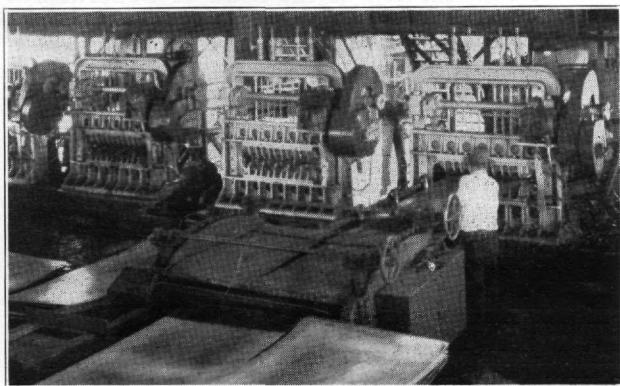


The ribbon of sheets entering a continuous annealing furnace

spond to the width of the specified sheet plus an allowance for shearing off the irregular edges following reduction. The thickness of the sheet when finished is determined by the width and gage of the sheet bar used. The sheet bars are heated in a pair furnace, so called because the bars are withdrawn from the furnace in pairs preparatory to being reduced on the roughing mill rolls.

In rolling 20 gage sheets a pair of heated sheet bars are taken to the roughing mill. The operator of this stand, known as the rougher, passes one of the bars crosswise between the rolls. It is caught on the other side of the mill by a workman known as the catcher who grasps the bar between the jaws of a pair of tongs and returns it over the top of the rolls to the front side. Meanwhile the rougher feeds a second bar into the rolls. This bar makes its initial pass as the first bar is returning. The bars are usually given five passes, the screws being turned down after each pass to reduce the space between the rolls. In this manner the sheet bars are drawn out to a certain percentage of the finished length. The partially rolled sheets are then placed one on top of the other and are charged into another furnace, known as the sheet furnace. When reheated to the desired temperature they are rolled in two's on a separate stand of finishing rolls to the length and thickness specified. To recapitulate, in common sheet mill practice, sheet bars are the raw materials used, two furnaces, namely, a sheet and a pair furnace, are required for each mill consisting of a roughing and finishing stand; and the crew on each stand is composed of 9 men. Steel, from the time it enters the pair furnace until it leaves the finishing mill is manipulated entirely by hand and a common sheet mill, as mentioned briefly above, will produce on the average of 7.6 tons of sheets per turn of eight hours.

The new continuous mills of the American Rolling Mill Company are based upon proportional,



Stitching the sheets into a continuous ribbon for further processing

roll convexity. Prior to the experimental work underlying the development of this plant the universal belief had been that in order to roll sheets successfully the rolls must be as nearly true cylinders as possible. Experiments revealed, however, that a true cylinder cannot possibly roll wide, thin sheets. In fact, analysis of the old Welsh process showed that the active passes, that is, the space between the rolls while they are in engagement with the piece being rolled there between, were not always such that the rolls were truly cylindrical.

Although tradition has dictated that the rolling of sheets must be performed on only one set of rolls which were supposed to give their particular shape to the piece or pack, the discovery was made that the best controlled active passes were those in which the shape of the piece in the roll differed from the shape before entering it. This observation led immediately to the invention of the system of control which has removed to a large extent the limitations in width and thickness which had formed the stopping place of continuous rolling processes in the past.

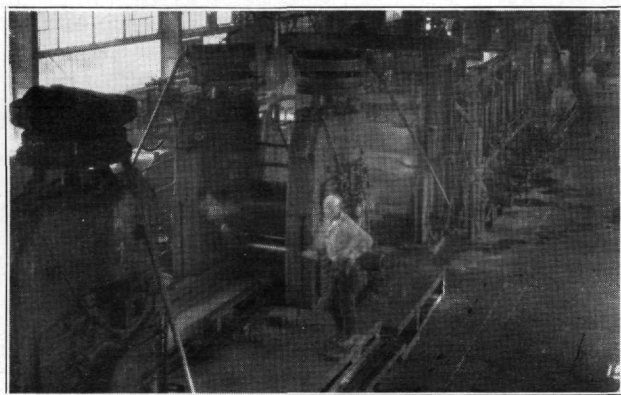
The basis for the new development lies in the control of the various factors going into the formation of the active pass so that a piece is rolled with a slight convexity and each active pass following the other cuts down the convexity and gives to the piece surfaces more nearly approaching parallelism.

The problem of using side guides to feed a thin, wide piece of metal into the gap of the rolls is thus eliminated because the rolling of slight convexity into the piece which is preserved but reduced in each pass forces the piece to travel through the roll stand in a straight line, as if in a closed stand.

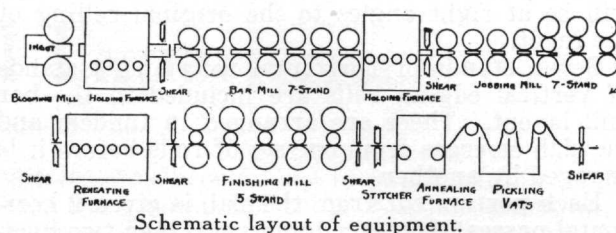
With true cylindrical active passes the piece will tend to travel toward the roll necks in a manner which side guides are completely inadequate to control because of the thin, wide character of the material being formed.

It is the mastery of the factors which cause the sheets to travel in straight lines through the trains of rolls that has made possible the assembly at the Ahland plant of The American Rolling Mill Company.

The following brief description of that plant is based upon information furnished by the operating company and from articles by John D.



Rolling the sheets to lighter gauges. The five-ton ingot is now a 20-gauge sheet



Schematic layout of equipment.

Knox, which have appeared during the past year in *Iron Trade Review*.

Little mention need be made of the history of the steel prior to the point where the ingot is ready for rolling. Molten iron and scrap steel are charged into the open hearth furnaces. Coke or natural gas is used for melting the charges and after the charge has been brought up to the desired chemical analysis it is cast into a ladle, and from there poured into the ingot molds. The ingots are 19 x 39 inches and weigh approximately 11,000 pounds. After the molds are stripped from them they are placed in soaking pits where their solidification is completed and where the excess heat is uniformly distributed and a sufficiently high temperature is obtained for the subsequent rolling of the ingot to 16 gage sheet.

When the ingot has reached the desired uniform heat it is picked out of the soaking pit and carried by an electrically driven chariot to the blooming mill where it is placed in a position between the side guards which guide it between the desired section of the rolls. These side guards are controlled from a pulpit which overlooks the approach table of the entry side of the mill.

The ingot after passing through the rolls from front to rear is received on a roller table which also is served by a pair of side guards. After the rolls are reversed the ingot is run between and returned to the front side. This is continued for as many passes as are required to reduce the 19 x 39 inch ingot to a slab 4 inches thick, 36 inches wide, and about 23 feet long.

Slabs intended for the continuous sheet mill, after being given the finishing pass, are conveyed on a roller table directly ahead for a distance of 124 feet from the center line of the blooming mill, where they enter the front end of a holding furnace. The purpose of this furnace is not to increase the temperature of the slab, but to preserve the initial heat so that as it emerges from the furnace its temperature will be uniform throughout. The furnace is 300 feet long and the progress of the slab is provided by 8 driven, water-cooled rolls.

The front end of the slab moves out of the rear end of the holding furnace and passes between the knives of a continuous acting shear. After the end is cropped, the remaining part of the slab is cut into such multiple lengths as are required for the finished product.

Each severed section is advanced by a chain conveyor to the first roll stand of the bar mill. Meanwhile the remaining portion of the slab is returned to the holding furnace to preserve its temperature until another cut is needed.

These severed portions, upon leaving the shear, are mechanically skewed around through a quarter turn so that they may be cross rolled, that is, the flow of metal during subsequent reduction

will be at right angles to the original rolling of the ingot.

Seven stands of horizontal rolls and 4 stands of vertical edging rolls are included in the bar mill layout. These are arranged in tandem and the slab emerges from one set of rolls before it is engaged by another.

Each portion cut from the slab is given 2 horizontal passes, then an edging pass, then two horizontal passes, then alternately an edging pass and a horizontal pass through the remainder of the tandem installation.

An accurate placing of the piece with regard to the stands of rolls in tandem is accomplished by using a table in which the rollers are arranged askew to the desired line of feed and in which the stands of rolls are offset slightly so as to be out of true center line with each other. The side guide in this case acts to enforce a straight line movement to the piece and the skewed rollers serve to keep the piece against the side guides. The purpose of staggering the roll stands is to permit the piece to become aligned to the side guides, thus avoiding the chance of jamming between rolls.

The slab, reduced in the 7 passes from 4 inches to 7/16th inch (plus or minus) leaves the last stand of the bar mill rolls at a speed of approximately 280 feet per minute and at the time of delivery is 312 feet and 8 inches from the blooming mill.

This sheet bar is conveyed straight ahead for a distance of 140 feet and charged into another holding furnace. This furnace serves the jobbing mill, is 30 feet long and is equipped with 9 motor driven, water-cooled rollers on which the metal travels in and out.

A continuous acting shear is installed about 10 feet from the discharge end of the holding furnace. This crops off the irregular front end of the sheet bar and then makes cuts at regular intervals of about 2 seconds until the bar is exhausted. Uniform lengths are obtained by a stop gage set at a predetermined distance away from the knives.

From this shear the material passes to the jobbing mill, which is a 7 stand unit, the first 4 stands being 2 high, and the last 3 being 3 high. In the 3 high mills reduction takes place between the bottom and the middle roll, which is smaller than the 2 extreme rolls. The purpose of the 3 high rolls is to permit of using a small roll in the center, which will sink deeper into the metal being rolled and thus reduce the metal quicker. Moreover such a small roll will cause less lateral spreading and will consume less power than the large rolls. The large top roll is for the purpose of strengthening the middle roll and preventing its springing as sheets are being reduced.

The steel, as it arrives at the last stand of the jobbing mill, is 593 feet from the blooming mill roll. While traveling this distance it is reduced from a slab 4 inches thick to a sheet bar 7/16th inches thick on the 7 stand bar mill, and from a 7/16th bar to a sheet 1/16th thick on the jobbing mill. All this is accomplished without any reheating or manual operation.

Sheets coming from the jobbing mill, after being inspected and if for high grade sheets, pickled,

are sheared both at the ends and sides and are matched, that is, 2 sheets are made into a pack.

These packs travel through a 140 foot continuous heating furnace and are then cut into sections before being served to the 5 stands of 3 high sheet mill rolls, installed in tandem.

Reduction of the metal in the hot mills leaves the grain structure in a distorted and strained state which must be relieved before further working can take place. This calls for annealing. At the Ashland plant this is done continuously by stitching the sheets together, end to end, to form a continuous strip of sheets. In shearing the sheets before they are passed through the annealing furnace the irregular ends are trimmed just far enough back to provide a straight edge for aligning the pieces preparatory to stitching. Sheets are overlapped about 1½ inches and stitching consists of punching 2 parallel cuts 2 inches long and a half-inch apart through the 2 thicknesses of metal. At the same time a vertical cut which connects the 2 slits at the centers is made, thus forming a complete slit corresponding to a letter "H" turned on its side. A forming head now bends the portion between these slits away from each other through an arc of 180 degrees, clasping the sheets tightly together. Such stitches are spaced about 6 inches apart along the joints between the sheets.

The sheets while in this continuous strip are passed through the annealing furnace and then through pickling vats and washing tanks and are then led to a shear which trims off the overlapping ends and permits the sheet to be handled separately again. The method of annealing described above insures uniform metal structure, for all sheets are uniformly exposed to the same temperature over the same length of time.

From this point on, the treatment which the sheets receive depends upon the type of product desired and the subsequent steps do not differ materially from those of the old methods of sheet manufacture. Some finishes require the stock to be full cold rolled, re-annealed and deoxidized, others require an interchange of these treatments.

In this description it has been assumed that the metal in process travels continuously through the whole train of operations. The actual layout, however, permits of very flexible operation, the scheduling of the material through the equipment being variable at each operation, and the product may be diverted to storage or shipping at any point.

We seem to have a poet in the M. E. Department. The following is merely a sample

When winter comes and freezes o'er
Old Mirror Lake from shore to shore,
We vote the old bridge game a bore,
And all go out a skating.

Frosty whiskers—icy nose,
Chattering teeth and frozen toes;
All for pleasure, so it goes,
When we go out a skating.

By NICK L. PENNY.

APRIL, 1928